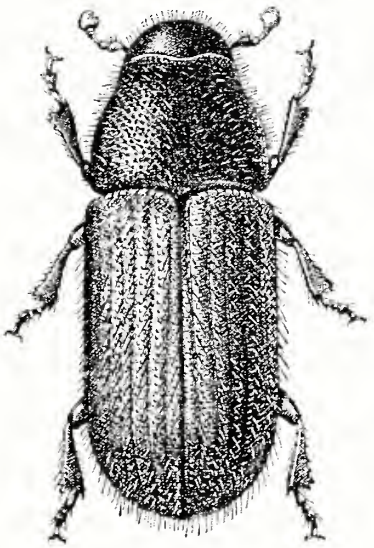
Forest Health Technology Enterprise Team

TECHNOLOGY
TRANSFER

Identification of Bark Beetles

A Guide to Common Bark Beetles (Coleoptera:Scolytidae) Endemic to the Northeastern United States



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USDA United States Department of Agriculture

Forest Service

FHTET-98-15
April 1999

ACKNOWLEDGMENTS

We are thankful to the many individuals who provided support and assistance during the development of this guide. H. Brenton Teillon, Dennis Souto, Robert J. Rabaglia, Richard G. Dearborn, Richard E. Hoebeke, and Mark Michaelis were supportive of the project from the onset. Richard G. Dearborn, Robert J. Rabaglia, and Donald S. Chandler provided beetle specimens. Donald E. Bright, Stephen L. Wood, Richard G. Dearborn, Robert J. Rabaglia, Richard E. Hoebeke, Ross T. Bell, Joyce R. Bell, Douglas C. Allen, and Barbara S. Burns reviewed the manuscript and provided helpful suggestions for improvements. We are grateful to Kathleen R. Decker and John St. Arnauld for technical assistance. We thank Roberta Burzynski for editing, and Tinathan Coger for layout and design and for printing advice and coordination of the manuscript. The following organizations provided funding: USDA Forest Service, Northeastern Area State and Private Forestry; the USDA Forest Service, Forest Health Technology Enterprise Team, Morgantown, West Virginia; and the USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine.

Cover Illustration: *Dendroctonus rufipennis* from Hopkins, A.D. 1909. Practical information on the scolytid beetles of North American forests. I. Bark beetles of the genus *Dendroctonus*. Bulletin 83(1). Washington, DC: U.S. Department of Agriculture, Bureau of Entomology; 169p.

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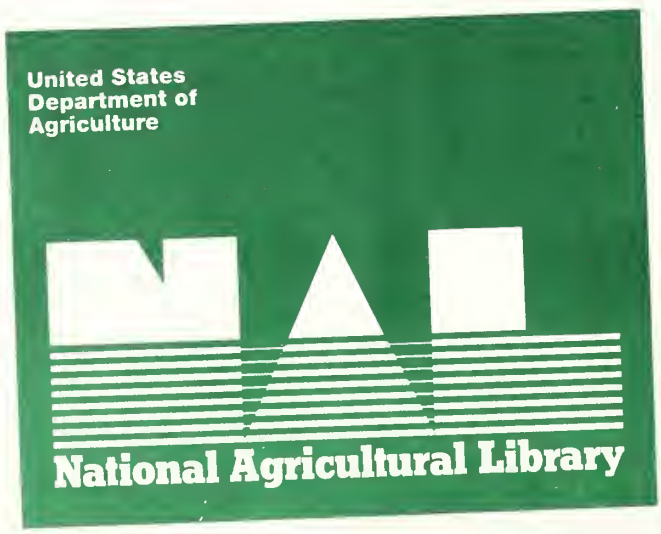

CONTENTS

FOREWORD

We have written this guide to aid foresters, biologists, and amateur naturalists in identifying some of the more common endemic bark beetles found in the Northeast. The Scolytidae are a diverse family, represented by approximately 100 species in New England and New York. In natural forest ecosystems, bark beetles play a vital role in maintaining vigorous growth by culling weakened or injured trees, and recycling dead plant tissue. At outbreak population levels, however, several bark beetle species are considered to be among the most serious pests in managed timberland and urban forests. Field sightings in the 1990s of several exotic scolytid species in the Northeast also suggest that potentially harmful introduced populations have established themselves in the region. With such a tremendous diversity of bark beetle species and behaviors in our forests, it is essential that we be able to identify at least our common endemic species, as well as recognize the arrival of exotic species. By becoming more familiar with the bark beetles common in our area, we can manage our forests more effectively, and add substantially to our knowledge of regional species diversity.

The 15 species described in this guide were chosen after consultation with bark beetle specialists throughout the Northeast. They represent 11 genera commonly seen in New York and New England, all but one of which colonize coniferous trees. All are phloem-feeders. Of course, there are many scolytid genera in the Northeast, some of them fairly common, that are not included in the guide. In the event that the reader wants more detailed information on a particular species, including those not described here, we have provided a thorough selection of references. This guide can also be used in conjunction with *Screening Aids for Exotic Bark Beetles in the Northeastern United States* (Cavey and Passoa 1994), which describes six exotic species now suspected to be in or en route to the United States. Many similar-looking endemic species, with which the exotics are likely to be confused, are included in this guide.

Almost all of the information contained in this publication, including illustrations and photographs, comes from three sources: *The Bark Beetles of Canada and Alaska* (Bright 1976), *Forest Ecology: Ecology and Management* (Coulson and Witter 1984), and *The Bark and Ambrosia Beetles of North and Central America (Coleoptera: Scolytidae), a Taxonomic Monograph* (Wood 1982). These references are all excellent resources for anyone seeking more information on bark beetles. Additionally, Wood and Bright (1987, 1992) provide a complete catalog of Scolytidae and a thorough bibliography of literature from around the world.

A Guide to Common Bark Beetles (Coleoptera:Scolytidae) Endemic to the Northeastern United States

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INTRODUCTION

This guide describes the natural history and morphology of scolytid beetles. It provides an identification key to 11 genera common in the northeastern United States, focusing on 15 phloem-feeding species:

Hylurgops rugipennis pinifex (Fitch)
Hylastes porculus Erichson
Hylesinus aculeatus Say
Dendroctonus valens LeConte
Dendroctonus rufipennis Kirby
Dendroctonus simplex LeConte
Polygraphus rufipennis (Kirby)
Scolytus piceae (Swaine)
Pityogenes hopkinsi Swaine
Pityokteines sparsus (LeConte)
Orthotomicus caelatus (Eichhoff)
Ips calligraphus (Germar)
Ips pini (Say)
Ips borealis borealis Swaine
Dryocoetes autographus (Ratzeburg)

The nomenclature follows Wood and Bright (1992). The guide also provides keys to three *Dendroctonus* species and three *Ips* species. In order to use all the keys effectively, be sure to read the section "Using the Identification Keys."

Descriptions for each of the 15 species include the following information: a common name (if one exists); a diagnosis summarizing the most obvious and distinctive morphological features; host plant species in the Northeast and colonization habits; a brief summary of the life history; a narrative summary of distribution within the Northeast (New England and New York), North America, and the world; a list of other species (including established introduced species) within the genus that are known to occur in the Northeast; a brief description of any similar-looking exotic species included in Cavey and Passoa (1994); and one or more references that can provide more detailed information.

Ecological Role of Bark Beetles

Members of the family Scolytidae, generally referred to as bark beetles, occur worldwide wherever woody plants grow. Of approximately 500 species found in North America, fewer than 100 have been recorded in the northeastern United States. Many species of bark beetles have been studied intensively and are well known to forest managers, as beetle habits can have considerable economic impact on managed forests. In the United States, insects kill more trees each year than any other natural agent, and well over half of this insect damage is caused by scolytids. Although some species have acquired notoriety as harmful pests in managed forests, bark beetles play a vital role in the natural evolution and ecology of forests. Most species of bark beetles are primary colonizers of recently felled or injured trees that are already in the process of dying. By feeding on host plant tissue, and by making their hosts more susceptible to colonization by other disease-causing or saprophytic organisms, bark beetles speed up the processes of decomposition and nutrient recycling that drive ecological succession in healthy natural forests.

Host Specificity and Conditions for Colonization

Spruces, firs, and pines are the most common hosts for North American scolytids, although other coniferous and deciduous species, as well as a few nonwoody plants, also serve as hosts. Most bark beetles feed and reproduce in a single or limited number of host species. While one tree may be colonized by several scolytid species, each species usually restricts its colonization efforts to a particular portion of its host (i.e., the crown, larger limbs, lower trunk, large roots). Many scolytids are also specific in their preference for colonizing standing trees, felled trees, or slash in varying stages of deterioration. Under normal conditions, most species colonize only injured or recently dead trees; relatively few taxa — some species of *Dendroctonus* among them — will infest healthy trees. Even among some of the species considered to be secondary invaders, however, outbreaks may occur in healthy forests when neighboring areas have been subject to either natural disturbance (i.e., fire, windthrow, flooding) or human mismanagement (i.e., poor logging practices). Bark beetle populations may escalate to such high numbers in these disturbed areas that they begin to attack surrounding vigorous trees.

Feeding Habits

Although **bark beetle** is a common name often applied to the entire Scolytidae, this name is more accurately restricted to the phloem-feeding (Figure 1) scolytids. The other major feeding group within the Scolytidae is commonly known as the **ambrosia beetles**. Ambrosia beetles bore into the xylem (Figure 1) of the host, and feed on symbiotic fungi rather than directly on host tissue. Other less common sources of food for scolytids include cones, xylem tissue, the pith of small branches, and the roots or stems of a few nonwoody plants (i.e., clover). In this guide we describe only members of the phloem-feeding bark beetles. Other common phloem-feeders often associated with bark beetles include larvae of Cerambycidae (long-horned beetles), Buprestidae (flat-headed borers), and a few species of moths and flies.

Host Selection and Colonization

Among the Scolytidae, either males or females, depending on the genus, initiate colonization in host trees. Primary host selection is carried out by a few adult beetles that are usually guided in their flight by olfactory stimuli such as volatile oleoresins, terpene hydrocarbons, or alcohol given off by injured or dying host tissue. Dispersal may be random if there are no attractive odors in the air. Once it finds a suitable host, the pioneer beetle usually bores in through a leaf scar, a crevice in the bark, or under a patch of moss or lichen, often at the base of a branch or twig. A coniferous host, if alive, reacts to this initial intrusion by exuding pitch to

plug the wound in its tissue, which drowns the intruder. If the bark beetle succeeds in overcoming this host defense, a pitch tube is formed at the entrance hole. These telltale yellowish pitch tubes, comprised of pitch and frass (a mixture of boring dust and beetle excrement), are often evident on the bark of infested conifers.

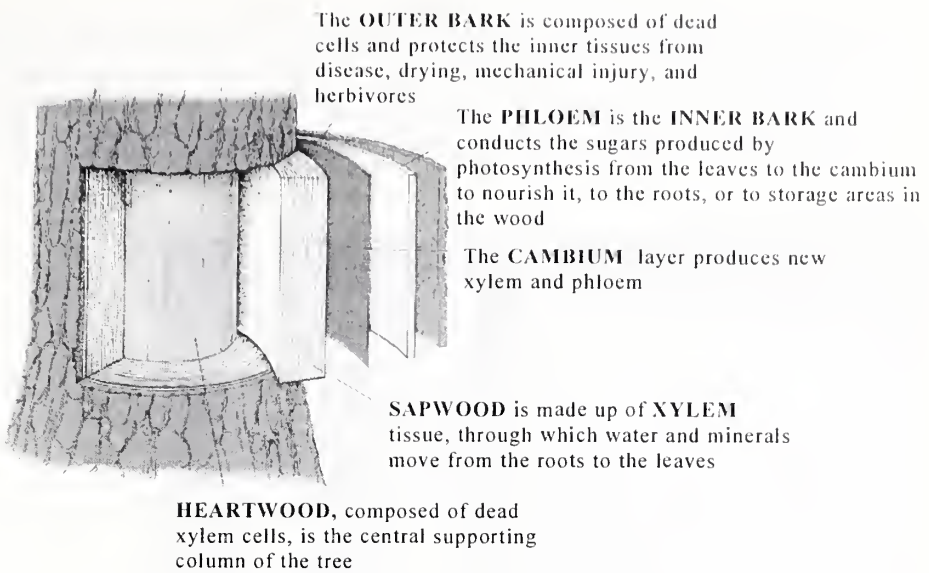


Figure 1. *Bark beetles feed on and reproduce in various functional parts of a tree (adapted from a drawing by Jack Kunz, in Ketchum 1970).*

Host-produced attractants, species-specific pheromones released by the pioneer beetle, or both, attract increasing numbers of adult beetles (forest entomologists take advantage of this aggregation habit by baiting scolytid traps with pheromones or tree volatiles). The pioneer beetle for each new gallery system identifies potential mates arriving at the entrance hole by sound, behavioral, chemical, or tactile stimuli. Eventually, a mass attack of bark beetles may overcome even vigorous host resistance. *Dendroctonus* and other destructive species introduce fungi that eventually clog the transport vessels of the sapwood in their live hosts (Figure 1), inhibiting their ability to take up water and thereby suppressing the flow of pitch into the galleries. The galleries themselves interrupt the vital flow of nutrients in the phloem of the host, eventually killing the tree.

Infested trees may be recognizable in the field by their yellowing foliage, pitch tubes, or flaking bark where woodpeckers have been feeding on the beetles. After a brood of beetles emerges, patches of bark are punctured with emergence holes.

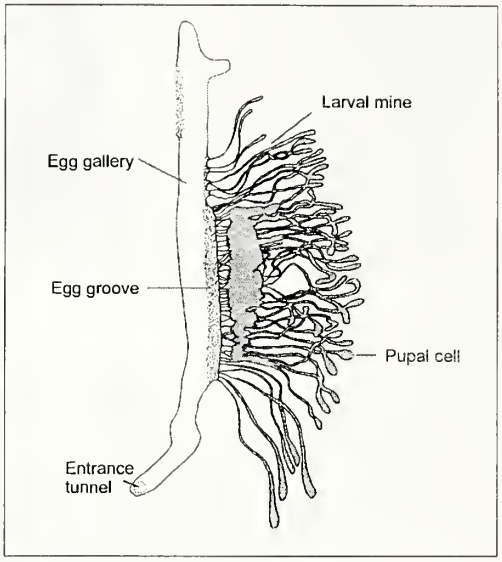
Galleries and the Life Cycle

Many bark beetle species can be identified by the unique pattern of their gallery systems, where mating, egg laying, feeding, and larval maturation occur (Figure 2, page 4). In polygynous species, the pioneer beetle is usually male. After excavating a flattened nuptial chamber in the cambium at the end of his entrance tunnel, he admits and mates with two to five females. Gallery construction continues as each female excavates her own egg gallery. In monogynous species, the pioneer beetle may be male or female. If the pioneer beetle is female, she may or may not construct a nuptial chamber before mating and excavating her egg gallery. There are usually one to several separate elongate egg galleries extending away from the entrance tunnel or nuptial chamber in different directions (Figure 2). The division of labor between the sexes in tending the gallery system (i.e., excavation, frass removal, preparation of egg niches) varies among scolytid taxa, and may have led to the evolution of sexual dimorphism in the groups. Depending on the species, each female may lay a single egg or as many as 200 or more in a gallery system, usually cutting egg niches into the sides of the galleries and depositing one egg or more in each niche. Some species of *Dendroctonus* excavate elongate egg grooves on the sides of the gallery (Figure 2c) where they lay their eggs in clusters or rows. Although the timing varies with climate and species, most eggs hatch in 7 to 10 days.

After hatching, larvae either feed communally in an enlarged parental gallery or excavate individual mines, usually at right angles to the egg galleries. These mines may engrave the sapwood (as in *Ips* or *Scolytus*, often referred to as engraver beetles) or bark, or both. The larvae often expand the ends of their mines to form individual cells where they will pupate (Figure 2c). The larval period usually lasts from 1 to 3 months, and most larvae go through two to five instars or growth stages. Pupation generally lasts between 6 and 9 days.

(a) *Polygraphus rufipennis*

(b) *Pityogenes hopkinsi*



(c) *Dendroctonus rufipennis*

Figure 2. *Patterns of gallery systems vary among scolytid genera and species: (a)* ***Polygraphus rufipennis*** *(reprinted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998); (b)* ***Pityogenes hopkinsi*** *(reprinted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998); (c)* ***Dendroctonus rufipennis*** *(adapted from Wood 1982 with permission of Great Basin Naturalist Memoirs, Brigham Young University).*

New adult bark beetles may spend some time feeding before they emerge from their host, or they may emerge immediately through individual exit holes and fly to a new host to feed for a time before reaching reproductive maturity. Typically, 80 to 90 percent of the initial brood will perish before emergence as a result of factors such as parasitization (by flies, wasps, nematode worms), predation (by other beetles, flies, ants, woodpeckers, amphibians, reptiles, rodents), competition from other phloem-feeders, disease, genetic defects, or extreme weather. After emergence, bark beetles may fall victim to some of these same forces before locating a new host, or they may be killed by host defenses.

The entire scolytid reproductive cycle can take anywhere from 20 days to 2 years. Mated adults either die in the gallery or reemerge to colonize other trees. Although some species have overlapping generations and all developmental stages may be found at any one time, the life cycle of a species is usually synchronized with the seasons. In the northern climes, for instance, the developmental stage most resistant to low temperatures (commonly the larval stage, but this may vary among species) predominates during the winter. As the cold weather approaches, activity generally ceases. Some scolytids prepare for winter by boring into the sapwood or outer bark of the brood tree, others by flying to living trees and excavating feeding tunnels in green bark or wood, and others by moving into the duff on the forest floor.

MORPHOLOGY

This section briefly describes the features of the head, thorax, and abdomen (Figure 3a) that are diagnostic for scolytid taxa. It is not intended to provide a complete description of scolytid morphology. The glossary further defines morphological terms used in the keys and species descriptions.

Head

Frons: The frons is the area between the eyes that extends down to the epistoma (Figure 3a and Figure 18, page 16). The frons may be concave or convex, and variously modified with punctures, carinae, tubercles, or setae. The shape and ornamentation of the frons distinguishes the sexes in many species.

Epistoma: The epistoma is a thickened, heavily sclerotized region below the frons (Figure 3a). The epistoma provides rigid support for the articulation of the mouthparts. In the genus *Dendroctonus*, the upper margin of the epistoma is modified by an epistomal process (Figure 3a and Figure 18, page 16), which varies in width and shape between the species. The epistomal margin usually bears a fringe of stiff, light-colored setae.

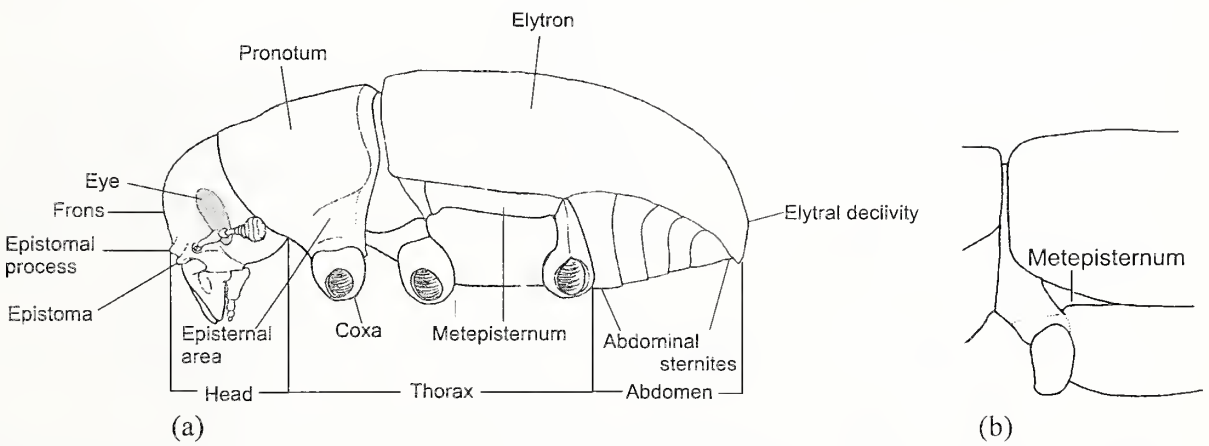


Figure 3. *Lateral view of a scolytid (legs are absent) shows these morphological features: (a) general morphology, the metepisternum is fully visible to its posterior margin (adapted from Hopkins 1909); (b) the posterior portion of the metepisternum is concealed by the elytra (adapted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).*

Eyes: The eyes are situated on the side of the head just posterior to the antennal insertions. The eye may be entirely oval in shape (Figure 4a), have a slight sinuation or moderate emargination in its anterior margin (Figure 4b), or have a deep emargination that appears to completely divide the eye (Figure 4c).

Figure 4. *Lateral views of scolytid heads show the variety in the shape of the eyes: (a) entire (adapted from Hopkins 1909); (b) emarginate (adapted from Wood 1982 with permission of Great Basin Naturalist Memoirs, Brigham Young University); (c) divided (adapted from Hinton 1968 with permission of the Natural History Museum, University of Kansas).*

Antennae: The antenna is generally shaped as shown in Figure 5 and consists of three parts: the scape, the funicle, and the club. The funicle has one to seven segments and is often used in classification, however, we have omitted it from this key because the segments can be difficult to count without high-power magnification. The antennal club is also extremely variable (Figure 13, page 11). Sutures may be transverse (Figure 13f), sinuate (Figure 13e), recurved (u-shaped) (Figure 13d), or procurved (n-shaped) (Figure 13b). The club may be regularly segmented with transverse or arcuate sutures on both faces (Figure 13f,h,i), or it may be asymmetrical with sutures displaced towards the apex of the posterior face (Figure 13b), or absent from the posterior face (Figure 13e) (note that Figure 13a-i shows only anterior faces of antennal clubs). Alternatively, the club may be obliquely truncate, thickened at the base with the apical segments appearing more or less telescoped at an oblique angle (Figure 13a,c,d), or it may be unsegmented with no visible sutures (Figure 13g).

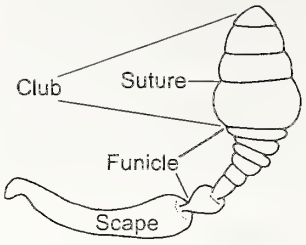


Figure 5. Variations in the basic morphology of a scolytid antenna aid in beetle identification (adapted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).

Thorax

Prothorax: The prothorax is the first segment of the thorax (Figure 6). There is considerable variation in the shape and sculpture of the dorsal piece of the prothorax, or pronotum (Figure 3a, page 5), especially of the central portion, or pronotal disc (Figure 7). The relative smoothness of the episternal area of the prothorax (Figure 3a) is used to help identify some species of *Dendroctonus*. Various features of the ventral piece of the prothorax, or prosternum (Figure 6), are also used to differentiate some scolytid taxa.

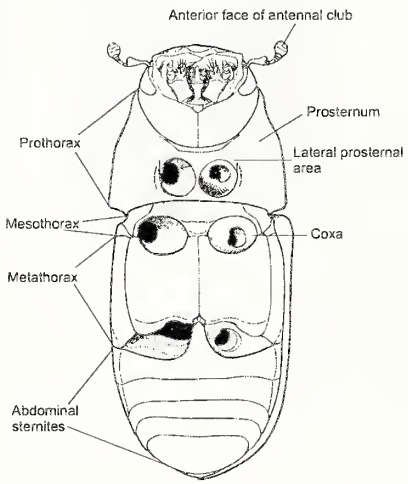


Figure 6. Ventral view of a scolytid (legs are absent) shows morphological features, some of which are used to differentiate taxa (adapted from Hopkins 1909).

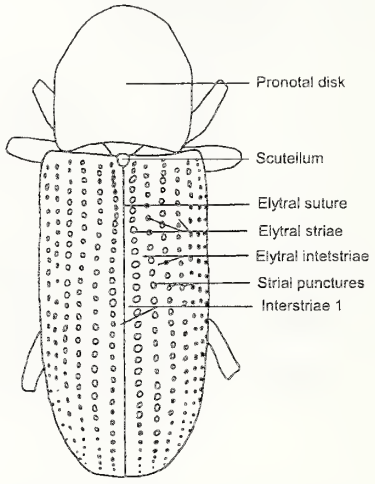


Figure 7. Dorsal view of a scolytid shows morphological features of the elytra (adapted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).

Legs: The shape and ornamentation of the tibia and tarsus are variable (Figure 8). The third tarsal segment may be bilobed, emarginate, or entire. The relative distance between the prothoracic coxae (Figure 6) is also used in classification.

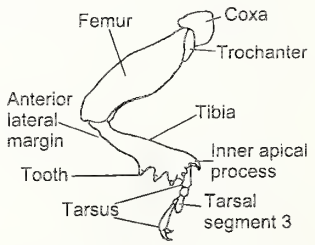


Figure 8. Lateral view of a prothoracic leg shows morphology and ornamentation (adapted from Hopkins 1909).

Elytra: Figure 7 shows the general morphology of the elytra. The elytral suture runs longitudinally down the midline of the dorsum and marks the junction of the elytra. Running parallel to the suture, the impressed elytral striae usually bear rows of punctures; the spaces between the striae are the elytral interstriae. The ten striae and eleven interstriae on each elytron are numbered, beginning from the elytral suture and counting outwards to the lateral margins (so that interstriae 1 lies between the elytral suture and stria 1). The shape and sculpture of the elytra are extremely variable. The posterior portion of the elytra that curves down to the apex is the elytral declivity (Figure 3a, page 5).

The declivity may be variably steep, convex (Figure 9a) or concave (Figure 9b), smooth or armed with spines, teeth, or pubescence (Figure 9b and Figure 14, page 12). In the genus *Scolytus*, the declivity is almost absent and the elytra are sometimes nearly flat to the apex (Figure 9c). If teeth are present on the declivity, they are numbered consecutively beginning with the anterior-most tooth (Figure 21a, page 26).

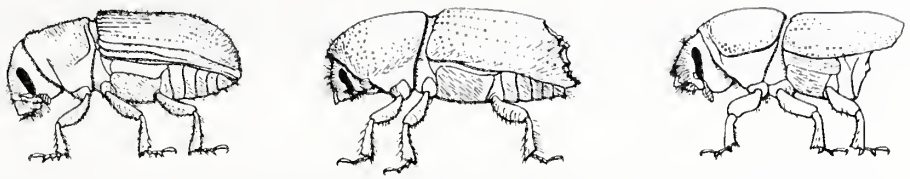


Figure 9. *Lateral views of scolytids show the variability in shape and ornamentation of the elytral declivity: (a) convex — **Dendroctonus** sp.; (b) concave with teeth — **Ips pini**; (c) almost absent — **Scolytus** sp. (reprinted with courtesy of Rudinsky and Ryker, Oregon State Agricultural Experiment Station).*

Scutellum: The scutellum is a small circular or triangular piece situated between the bases of the elytra (Figure 7). It varies in size, shape, and location relative to the bases of the elytra. In some species it is not visible.

Metepisternum: The metepisternum is a narrow, triangular plate that is variably covered by the elytron above it (Figure 3, page 5). In all genera described in this guide, the full length of the metepisternum is visible when the elytra are tightly closed (Figure 3a). This character is used in the key to eliminate several genera that are not included in this guide. In these genera, the elytra, when closed, cover at least the posterior two-thirds of the metepisternum (Figure 3b).

ABDOMEN

The abdomen (Figure 3a, page 5) is used in the classification of *Scolytus* and related genera. In most species of *Scolytus*, the abdominal sternites ascend abruptly to meet the elytra (Figure 9c and Figure 19, page 21). The sternites vary in length, concavity, and ornamentation. The five visible sternites are numbered consecutively beginning with the anterior-most visible sternite. The last sternite may also be modified in some other genera.

A note on body color: The color of the elytra, pronotum, underside of the body, or all of these is often given as a diagnostic character for scolytid species. These color descriptions are generally appropriate only for well-preserved mature specimens, and even among these, some color variability is common. Recently transformed young adult bark beetles or poorly preserved specimens may be lighter in color than the species diagnosis suggests.

USING THE IDENTIFICATION KEYS

The identification keys to genus and species have been designed so that scolytid taxa not covered in the guide will not key out successfully. Therefore, it is important that your specimen matches all the parts of a couplet before you proceed in the key. If neither description in the couplet fully matches your specimen, it likely is a genus or species not included in this guide. Photographs accompanying the key to genera are provided to show generic characters only, and some of the species (labeled as *Genus* sp.) portrayed in these photographs are not described in this guide. For all species, we have provided a species diagnosis and a list of other northeastern species within the genus. Again, to confirm the species of your beetle, make sure that the all parts of the species diagnosis match your specimen.

KEY TO GENERA

Adapted from Bright (1976) and Wood (1982)

1. Elytra slightly or not at all declivous behind, abdomen ascending abruptly to meet them (Figure 9c, page 7); anterior lateral margin of prothoracic and metathoracic tibiae unmodified except for a single, long curved process at outer apical angle that curves toward the smaller inner apical process (Figure 10a, page 10) ..... ***Scolytus* Geoffroy**, p.21

   Elytra declivous behind, descending to meet the horizontal abdomen (Figure 9a,b, page 7); anterior lateral margin of prothoracic tibiae with several tooth-like processes, none of which curve toward the inner apical process (Figure 10b,c, page10) 2

2. Scutellum large and flush with elytral surface, its anterior margin and elytral bases forming a transverse or slightly recurved line across the body (Figure 11a, page 10); pronotum roughened by asperities on anterior portion (Figure 11a) (less so in *Dryocoetes*); head usually concealed from above (Figure 11a); anterior margins of elytra usually smooth and either rounded or with a fine raised line; metepisternum visible to its posterior extremity when elytra are tightly closed (Figure 3a, page 5) (if metepisternum is largely concealed by elytra, visible only in front when elytra are closed (Figure 3b), then genus is not included in this key) 3

   Scutellum, if visible, rounded, somewhat depressed and usually displaced posteriorly causing a slight emargination between bases of elytra (Figure 11b,c,e,f, page 10) (emargination may be almost obsolete in *Hylastes* (Figure 11d)); pronotum punctate and usually smooth, with few or no asperities (Figure 11b-f); head usually slightly to distinctly visible from above (Figure 11b-f); anterior margins of elytra raised and usually bearing a row of crenulations (Figure 12, page 11) (except in some *Hylastes* and *Hylurgops*) 7

3. Elytral declivity smooth, or granulate at most; pronotum either punctate or finely asperate over almost entire surface, dorsal profile evenly convex, not strongly declivous anteriorly, anterior margin smooth; antennal club obliquely truncate (Figure 13a, page 11); eye emarginate but never completely divided; prothoracic coxae contiguous or nearly so; scutellum large ..... ***Dryocoetes* Eichhoff**, p.30

   Elytral declivity with teeth (Figure 14, page 12) (may be quite small in *Pityogenes* female (Figure 20a, page 22)); pronotum more coarsely asperate and more strongly declivous anteriorly, anterior margin sometimes with erect asperities; antennal club, eye, coxae, scutellum size all variable; mesothoracic and metathoracic tibiae abruptly narrowed apically, with a few widely spaced coarse teeth (Figure 10b, page 10) (several genera of ambrosia beetles not included in this key have mesothoracic and metathoracic tibiae broadly dilated to a point slightly beyond the middle then gradually narrowed to the apex, with a series of closely set teeth all about the same size and shape (Figure 10c) 4

4. Elytral declivity with two narrow parallel medial grooves, margins moderately elevated, rounded; declivity with no more than three teeth; lower margins of declivity rounded (Figure 14a, page 12).. 5

   Elytral declivity broadly and rather deeply excavated, margins acutely elevated; declivity with three to six teeth; lower margins of elytral declivity with a shelf or elevated ridge before apex (ridge less pronounced in *Orthotomicus*) (Figure 14b,c, page 12) 6

5. Antennal club circular to transversely oval, with two sutures visible on anterior face and on distal third of posterior face (Figure 13b, page 11); female frons deeply, narrowly excavated (Figure 15a, page 12); prosternal intercoxal piece short, obtuse, and often difficult to see (Figure 16a, page 12) ..... ***Pityogenes* Bedel**, p.22

   Antennal club obliquely truncate, without sutures on posterior face (Figure 13c, page 11); female frons convex, not excavated, frons and anterior portion of pronotum with long and abundant setae (Figure 15b, page 12); prosternal intercoxal piece long and acutely tapered (Figure 16b, page 12) ..... ***Pityokteines* Fuchs**, p.23

6. Antennal club obliquely truncate, the sutures recurved (Figure 13d, page 11); elytral declivity steep, moderately excavated, the third tooth displaced mesally from summit of declivital margin (Figure 14b, page 12) ..... ***Orthotomicus* Ferrari**, p.24

   Antennal club not obliquely truncate, flattened, the sutures transverse, procurved, or bisinuate (Figure 13e, page 11); elytral declivity not as steep, broadly excavated, all teeth on summit of declivital margin (Figure 14c, page 12) ..... ***Ips* DeGeer**, p.25

7. Lateral prosternal area (Figure 6, page 6) sharply angular, with elevated ridge from coxa to anterior margin of prosternum; antennal club conical, segment 1 distinctly longer than segment 2 (Figure 13f, page 11); head somewhat prolonged (Figure 17a, page 12); crenulations on elytral bases poorly developed; eye entire (Figure 4a, page 5); prothoracic coxae narrowly separated, almost contiguous 8

   Lateral prosternal area (Figure 6, page 6) rounded, without elevated ridge from coxa to anterior margin of prosternum; antennal club at least slightly flattened, segments variable; head not prolonged (Figure 17b, page 12); crenulations on elytral bases usually well-developed (Figure 12, page 11); eye variable; prothoracic coxae variable 9

8. Pronotum usually constricted anteriorly (Figure 11c, page 10), about equal numbers of large and small punctures intermixed on disc; rows of longer, erect, hair-like interstrial bristles on elytral declivity ..... ***Hylurgops* LeConte**, p.13

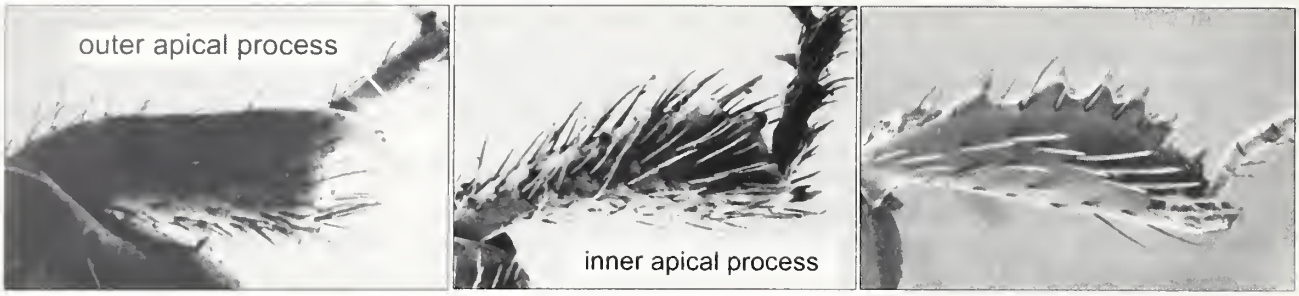
   Pronotum not noticeably constricted anteriorly (Figure 11d, page 10), punctures on disc uniformly large, rarely intermixed with a few small punctures; hair-like interstrial bristles on elytral declivity, if present, not longer than ground vestiture ..... ***Hylastes* Erichson**, p.14

9. Eye divided into two parts (Figure 4c, page 5); antennal club solid, unmarked by sutures (Figure 13g, page 11); scutellum not visible, elytral bases only slightly emarginate at suture (Figure 11e, page 10); ..... ***Polygraphus* Erichson**, p.20

   Eye entire (Figure 4a, page 5); antennal club with three sutures (Figure 13h,i, page 11); scutellum visible, elytral bases notched for its reception (Figure 11f, page 10); 10

10. Prothoracic coxae very narrowly separated, almost contiguous; vestiture hair-like; antennal club circular to transversely oval, strongly flattened (Figure 13h, page 11); epistomal process well-developed (Figure 18, page 16); stout body, 3.4 to 9.0 mm ..... ***Dendroctonus* Erichson**, p.16

    Prothoracic coxae widely separated; vestiture scale-like, characteristic color patterns rom various mixtures of white, tan, brown, or black scales; antennal club elongate, only slightly flattened (Figure 13i, page 11); epistomal process obsolete; body smaller, 2.0 to 4.0 mm ..... ***Hylesinus* Fabricius**, p.15



(a) *Scolytus* sp. (b) *Orthotomicus caelatus* (c) *Xyleborus* sp.

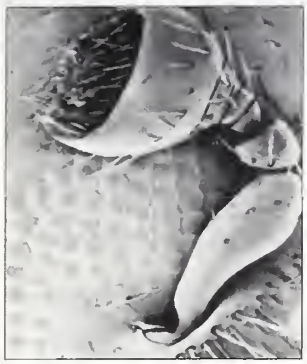
Figure 10. *The shape and ornamentation of tibiae vary among scolytids: (a)* ***Scolytus sp.****; (b)* ***Orthotomicus caelatus****; (c)* ***Xyleborus sp.*** *(adapted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).*

(a) *Ips pini* (b) *Hylesinus aculeatus* (c) *Hylurgops* sp.

(d) *Hylastes* sp. (e) *Polygraphus rufipennis* (f) *Dendroctonus* sp.

Figure 11. *Dorsal views of various scolytid genera show the variability in shape and sculpture of the elytra and pronotum, and visibility of the head and scutellum: (a)* ***Ips pini****; (b)* ***Hylesinus aculeatus****; (c)* ***Hylurgops sp.****; (d)* ***Hylastes sp.****; (e)* ***Polygraphus rufipennis****; (f)* ***Dendroctonus sp.*** *(reprinted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).*

Figure 12. *Raised anterior margin of an elytron shows crenulations (reprinted from Passoa and Cavey 1993).*

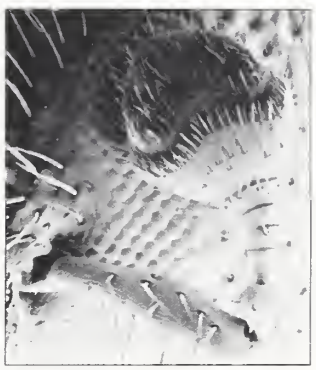


(a) *Dryocoetes* sp.

(b) *Pityogenes* sp.

(c) *Pityokteines* sp.

(d) *Orthotomicus caelatus*

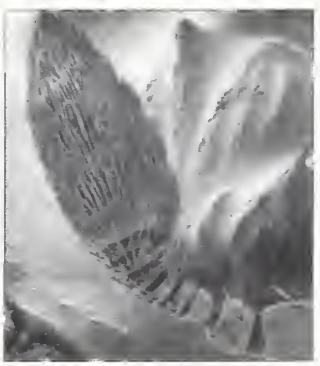


(e) *Ips pini*

(f) *Hylastes* sp.

(g) *Polygraphus rufipennis*

(h) *Dendroctonus* sp.

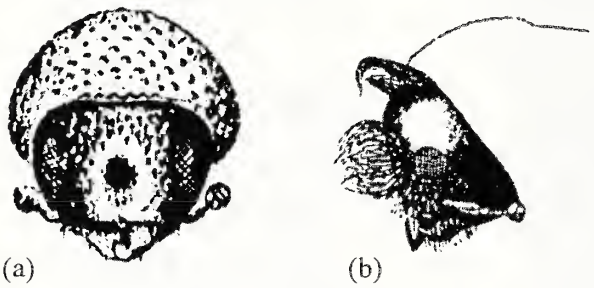


(i) *Hylesinus aculeatus*

Figure 13. *The shape of the antennal club and the arrangement of sutures on both the anterior and posterior faces are often diagnostic for scolytid genera and species, only anterior faces are shown here: (a)* ***Dryocoetes sp.****; (b)* ***Pityogenes sp.*** *(note that suture 1 on club of* ***P. hopkinsi*** *is straight, not arcuate as in the species shown here); (c)* ***Pityokteines sp.****; (d)* ***Orthotomicus caelatus****; (e)* ***Ips pini****; (f)* ***Hylastes sp.****; (g)* ***Polygraphus rufipennis****; (h)* ***Dendroctonus sp.****; (i)* ***Hylesinus aculeatus*** *(reprinted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).*

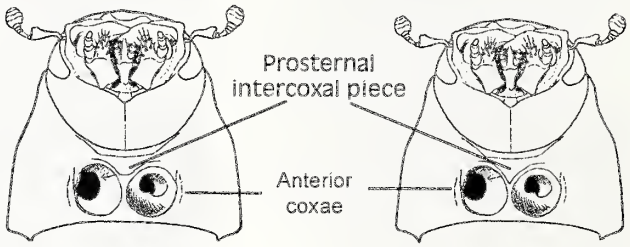
(a) *Pityokteines* sp. (b) *Orthotomicus caelatus* (c) *Ips pini*

Figure 14. *Elytral declivities may vary in width and depth of excavation, arrangement and size of the teeth, and shape of the apex: (a)* ***Pityokteines sp.*** *(female); (b)* ***Orthotomicus caelatus****; (c)* ***Ips pini*** *(male) (adapted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).*



(a) (b)

Figure 15. *Sculpture and vestiture on the frons of the female are diagnostic for two scolytid genera: (a)* ***Pityogenes hopkinsi*** *(female); (b)* ***Pityokteines sparsus*** *(female) (reprinted from Swaine 1918).*



(a) (b)

Figure 16. *Ventral views of two scolytids show the variable shape of the prosternal intercoxal piece: (a) short and obtuse (often difficult to see)—****Pityogenes sp.****; (b) long and acute—****Pityokteines sp.*** *(adapted from Hopkins 1909).*

(a) *Hylurgops* sp. (b) *Dendroctonus* sp.

Figure 17. *Lateral views of scolytids show the variability in prolongation of the head (a)* ***Hylurgops sp.****; (b)* ***Dendroctonus sp.*** *(reprinted from Bright 1976 with permission of the Minister of Public Works and Government Services Canada, 1998).*

DESCRIPTIONS OF GENERA AND SPECIES

Genus *Hylurgops* LeConte

Members of genus *Hylurgops* are characterized by the anteriorly constricted pronotum (Figure 11c, page 10), which, on the surface, bears an equal number of large and small punctures intermixed, and by the broad and bilobed third tarsal segment.

Hylurgops rugipennis pinifex (Fitch)

Diagnosis: Length 3.7-5.2 mm. Reddish brown to black on pronotum and elytra, ventral surface black. Sides of pronotum constricted in front of middle (Figure 11c, page 10); elytral interstriae convex with confused crenulations, granulate on declivity; vestiture on elytral declivity and part of disc consisting of recumbent, narrowly to broadly flattened scales and rows of longer, erect, hair-like interstrial setae; anterior portion of elytra without scales, covered with short, hair-like setae.

Host species and colonization habits: *Pinus* and *Picea* species, occasionally *Larix laricina*. Prefers the thick bark portion of trees, and usually colonizes stumps, logs, or the lower part of standing trees. It is also often found below ground level in the roots.

Life history: All species in the genus are monogynous. The female excavates a longitudinal egg gallery that most often extends downwards, or sometimes upwards, from the nuptial chamber for 2.5 to 9.0 cm. Galleries are primarily excavated in the phloem tissue, but may engrave the sapwood slightly. Females deposit between two and six eggs in niches on both sides of the gallery; the eggs are packed in frass. After hatching, the larvae feed communally, wandering aimlessly and excavating large areas of cambium. Pupation occurs in a pupal cell constructed in the phloem, cambium, or wood. In the Northeast there is probably one generation per year.

Distribution: Northeast records from Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont. North American records from inland British Columbia to Utah and Colorado then eastward to Nova Scotia and Alabama.

Other *Hylurgops* species known to occur in the Northeast: None.

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Hylurgops palliatus* (Gyllenhal). Differs from *H. rugipennis pinifex* in the following ways: shorter body length of 2.5-3.2 mm; scale-like vestiture on the elytra for their entire length, more numerous on the apical third; interstrial crenulations on elytra in a single row, rather than confused.

References: Blackman (1919), Bright (1976), and Wood (1982).

Genus *Hylastes* Erichson

Members of genus *Hylastes* can be difficult to distinguish from those in *Hylurgops*. They differ in having a pronotum not noticeably constricted anteriorly (Figure 11d, page 10), with punctures on the disc uniformly large, rarely intermixed with a few small ones, and by the narrower, emarginate third tarsal segment.

Hylastes porculus Erichson

Diagnosis: Length 3.8-5.3 mm. Body reddish brown to black. Frons broad between eyes, deeply, broadly, transversely impressed above epistoma, this impression divided by a distinctly elevated median carina which ends at epistomal margin; pronotum with moderately large, deep, close punctures; elytral punctures deep, very coarse; elytral interstriae scarcely rugose to granulate-punctate; last abdominal sternite of male with a wide, shallow groove with longer setae; elytral vestiture sparse, hair-like, becoming more scale-like on declivity.

Host species and colonization habits: *Pinus* species. All species of *Hylastes* colonize the phloem tissue of stumps, roots, and occasionally logs. The genus is generally of minor economic concern.

Life history: The life histories of the species within this genus have been little studied. The gallery systems are presumed to be similar to those of *Hylurgops*.

Distribution: Northeast records from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Vermont. North American records from Manitoba to Texas then eastward to New Brunswick and Florida.

Other *Hylastes* species known to occur in the Northeast: *H. tenuis* Eichhoff, *H. opacus* (Erichson). *Hylastes opacus* is a Palearctic species, first reported in North America in 1989, and now established in the Northeast (Hoebeke 1994, Rabaglia and Cavey 1994).

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Hylurgus ligniperda* (Fabricius). Differs from *Hylastes porculus* most noticeably in being covered with thick, long, reddish hairs.

References: Bright (1976), Drooz (1985), and Wood (1982).

Genus *Hylesinus* Fabricius

Members of genus *Hylesinus* are characterized by the densely scaly elytra and pronotum, the presence of scattered asperities on the lateral areas of the pronotum, the moderately ascending abdomen, and the deeply impressed elytral striae (Figure 11b, page 10).

Hylesinus (= Leperisinus) aculeatus Say

Common name: Eastern ash bark beetle

Diagnosis: Length 2.0-3.0 mm. Body dark brown with a variable, variegated pattern of white and dark brown scales on pronotum and elytra. Frons convex (female) or flattened (male), slightly impressed above epistoma, surface dull, punctate-reticulate, with a faint longitudinal carina, densely pubescent; anterior margin and lateral areas of pronotum with prominent asperities; suture 3 of antennal club strongly angulate; base of elytra with prominent asperities (Figure 11b, page 10), elytral interstriae with a median row of lower, blunt asperities barely discernible above scale covering.

Host species and colonization habits: *Fraxinus americana* and other *Fraxinus* species. Colonizes the trunk, limbs, and larger branches of recently felled, dying, or seriously weakened trees. The species is of little economic concern.

Life history: All species in the genus are monogynous. The female excavates the two arms of her egg gallery in opposite directions from the central nuptial chamber, across the grain. She then lays her eggs singly in niches on both sides of the egg gallery. After hatching, the larvae tunnel away from the egg gallery at right angles, following the grain of the wood, and usually do not cross each other. Both the egg galleries and the larval mines deeply engrave the sapwood. Young adults feed little, if at all, before emerging from their brood host. Adults overwinter outside the brood gallery system in individual shallow feeding and hibernation tunnels in the green bark of living or recently felled trees.

Distribution: Northeast records from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Vermont. North American records from Manitoba to Nova Scotia then southward to Colorado, Oklahoma, and Georgia.

Other *Hylesinus* species known to occur in the Northeast: *H. pruinosus* Eichhoff.

References: Bright (1976), Drooz (1985), and Wood (1982).

Genus *Dendroctonus* Erichson

Members of genus *Dendroctonus* are characterized by the usually large, stout body; the well-developed epistomal process (Figure 18); the subcircular, flattened antennal club having three weakly procurved sutures (Figure 13h, page 11); and the evenly convex elytral declivity.

Key to three common species of *Dendroctonus*

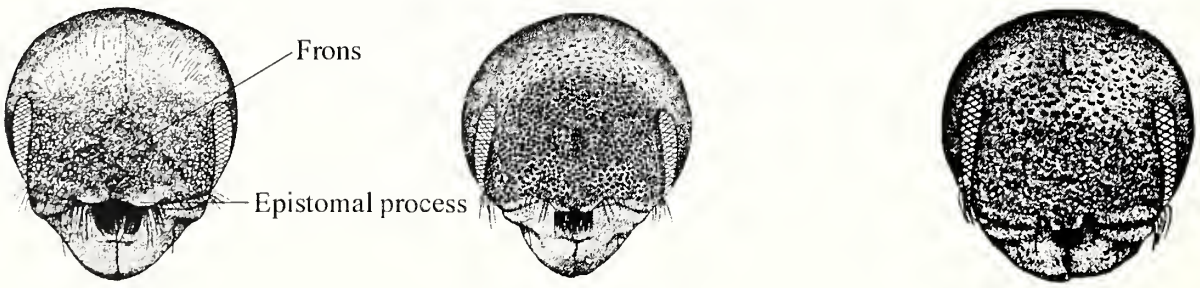
1. Generally larger body size, 5.3 to 9.0 mm; mature body uniformly red to reddish brown; epistomal process broad, transversely concave, its basal width about one-half as wide as the distance between the eyes (Figure 18a); episternal area of prothorax (Figure 3a, page 5) coarsely granulate, punctures obscure or absent ..... ***D. valens* LeConte,** p. 17

   Generally smaller body size, 3.4 to 7.0 mm; mature body brown to black, may have reddish cast on elytra; epistomal process narrower, its basal width no more than one-third as wide as the distance between the eyes (Figure 18b,c); episternal area of prothorax (Figure 3a, page 5) punctate, the granules minute or absent **2**

2. Declivital striae weakly or not impressed; declivital interstriae 1 weakly elevated, 2 as wide as or wider than 1 or 3 (except near apex); epistomal process transversely concave, basal width about one-third as wide as the distance between the eyes, lateral margins moderately oblique, about 45 degrees from horizontal (Figure 18b); frons closely, finely, granulate between close, deep punctures, punctures usually obscure in central area; larger body size, 4.4 to 7.0 mm; mature body color dark brown with reddish brown elytra, old adults usually uniformly black; from *Picea* ..... ***D. rufipennis* Kirby,** p.18

   Declivital striae strongly impressed; declivital interstriae 1 strongly elevated, 2 weakly impressed and narrower than 1 or 3; epistomal process transversely convex, basal width less than one-third as wide as the distance between the eyes, lateral margins strongly oblique, about 80 degrees from horizontal (Figure 18c); frons with rather coarse, deep punctures, and a very few minute granules; smaller body size, 3.4 to 5.0 mm; mature body color dark brown, elytra often with a reddish cast; from *Larix* ..... ***D. simplex* LeConte,** p. 19

Other *Dendroctonus* species known to occur in the Northeast: *D. terebrans* (Olivier), *D. punctatus* LeConte.



(a) *D. valens* (b) *D. rufipennis* (c) *D. simplex*

Figure 18. *Frontal views of three Dendroctonus heads show the variation in width and shape of the epistomal process: (a)* ***Dendroctonus valens****; (b)* ***Dendroctonus rufipennis****; (c)* ***Dendroctonus simplex*** *(reprinted from Wood 1982 with permission of Great Basin Naturalist Memoirs, Brigham Young University).*

Dendroctonus valens LeConte

Common name: Red turpentine beetle

Diagnosis: Length 5.3-9.0 mm. Mature body uniformly red to reddish brown. Frons irregularly convex; pronotal surface smooth, with close, shallow punctures, irregular in size; elytral striae weakly impressed with deep punctures; elytral interstriae with small, abundant crenulations; declivity steep, convex, feebly impressed between striae 1 and 3, granulate.

Host species and colonization habits: *Pinus* species; rarely *Abies concolor*, *Larix laricina*, and *Picea* species. The beetles are attracted by whole oleoresin, and most commonly colonize stumps of freshly cut trees, and injured, weakened, or dying trees, but in some areas they may select apparently healthy trees. Colonization on any one tree usually involves only a few pairs of beetles, and generally occurs at or near ground level. All species of *Dendroctonus* are associated with symbiotic fungi that modify host physiology and aid the beetles in overcoming host resistance mechanisms. By itself, this species causes little economic loss, it commonly arrives at a host already weakened by other more aggressive species. It may also predispose trees to attack by other scolytids.

Life history: As with all species in this genus, adults of *D. valens* are monogynous and the female initiates colonization. She constructs the entrance tunnel, and after reaching the cambium region she tunnels upward for a short distance. Depending on the amount of pitch she encounters, she may continue upwards or be forced downward into the roots. Ultimately, the shape of the egg gallery may be linear, branched, or an irregular cave shape. The gallery is usually expanded on one side and packed with granular reddish frass. The female lays her one hundred or more eggs either loose in the frass or in layers of ten to forty. The larvae feed communally in the phloem in a general direction away from the egg gallery, leaving reddish frass behind them. They may excavate a patch of phloem up to 20-30 cm across. Mature larvae construct their pupal cells either in the frass of the main feeding cavity, or in a separate tunnel in the phloem adjoining the cavity. Adults are capable of flights up to 16 km or more. Depending on the climate, it may take more than one year to complete a generation, or more than one generation may be completed in a year. Generations frequently overlap.

Distribution: Northeast records from Maine, Massachusetts, New Hampshire, New York, and Vermont. North and Central American records from the Northwest Territories to Nova Scotia then southward to Honduras, except not in southeastern United States.

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Hylurgus ligniperda* (Fabricius). Differs from *D. valens* in the following ways: the frons has a raised longitudinal tubercle near its apex; generally shorter body length of 4.0 to 5.7 mm; black-brown body color.

References: Bright (1976), Smith (1971), and Wood (1963, 1982).

Dendroctonus rufipennis **Kirby**

Common name: Spruce beetle

Diagnosis: Length 4.4-7.0 mm (see cover illustration). Mature body dark brown with reddish brown elytra, old adults usually uniformly black. Frons convex, punctures close, deep, rather fine, almost obscured in median area by fine, abundant granules; pronotal surface smooth, with fine, close, deep punctures irregular in size; elytral striae very weakly impressed on disc, punctures shallow; elytral interstriae with abundant, small, transverse crenulations; declivity steep, convex, interstriae almost smooth, confusedly punctate, the median punctures slightly granulate on upper rims.

Host species and colonization habits: *Picea* species. Prefers windfalls, freshly cut logs, shaded slash, and weakened standing trees. When harvesting operations, windthrow, or other disturbances create large accumulations of suitable host material, however, beetle populations can rise to outbreak levels and colonize standing trees of any size or vigor. In standing trees, colonization begins in the lower third of the trunk and usually progresses to the upper bole and stump later in the season. Piteh tubes usually form around beetle entrance holes and provide evidence of spruce beetle attack. In prostrate trees, colonization occurs only in the lower half next to the ground. The colonization cycle may last from a few days to many months, depending on the density of beetles, resistance of the host, and environmental factors. *Dendroctonus rufipennis* is the most destructive of the spruce-inhabiting bark beetles.

Life history: The species is monogynous and the female initiates colonization. She bores deep into the phloem and, after mating, continues excavating the egg gallery parallel to the grain. The gallery is an average of 13 cm long and almost straight, with a bend 1-2 cm above the entrance tunnel (Figure 2c, page 4). The female most often lays her eggs in grooves formed alternately on the sides of the gallery in contact with the cambium; she occasionally lays her eggs in individual niches. After oviposition, parents may extend the gallery a short distance to feed, and then usually reemerge to construct a second or third set of galleries. The larvae feed communally for about the first third of their development, at right angles to and away from the egg gallery. After this, they construct individual feeding mines that wind throughout the phloem, frequently crossing each other. Although it may overwinter in any stage of development, the spruce bark beetle is unique among *Dendroctonus* in its ability to overwinter as an adult. Overwintering larvae complete their development the following spring or summer. Pupation occurs in cells at the end of the larval mines or in the frass of a previously excavated area. Depending on the climate, its life cycle may take from one to four years to complete, although two years is most typical.

Distribution: Northeast records from Maine, New Hampshire, New York, and Vermont. North American records from Alaska to Newfoundland then southward to Arizona, New Mexico, Michigan, and Pennsylvania.

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Hylurgus ligniperda* (Fabricius). Differs from *D. rufipennis* in having the frons with a raised longitudinal tubercle near its apex.

References: Bright (1976), Dyer and Taylor (1968), Grant and Cottrell (1968), Martineau (1984), and Wood (1963, 1982).

Dendroctonus simplex Le Conte

Common name: Eastern larch beetle

Diagnosis: Length 3.4-5.0 mm. Mature body dark brown, elytra often with a reddish cast. Frons convex, with coarse, deep, close punctures; epistomal process flat, overlapping, and nearly flush with epistomal margin (Figure 18c, page16); pronotal surface smooth, the punctures coarse, close, deep, irregular in size; elytral striae weakly impressed on disc, punctures deep; elytral interstriae bearing an irregular row of transverse crenulations; declivity steep and convex, striae deeply, narrowly impressed, interstriae 1 strongly elevated, interstriae coarsely punctate, without granules (male), or with fine punctures and tubercles (female).

Host species and colonization habits: *Larix laricina.* Colonizes dying or injured trees, windfalls, snow breaks, and stumps. *Dendroctonus simplex* has caused mortality in stands weakened by drought, fire, flooding, or attacks by other insects. Where populations of this species have built up to large numbers, it has been known to kill nearby healthy, mature larches, but it is not generally considered to be a widespread economic threat.

Life history: The species is monogynous, and the female initiates colonization. She constructs a vertical, slightly sinuate egg gallery, about 20-25 cm long, in which she deposits groups of three to six eggs, or more, in grooves along the gallery wall. After oviposition, parent adults may reemerge to construct a second or third set of galleries during the season. The larvae mine individually away from the egg gallery, without crossing each other, and keep in contact with the cambium. The larval mine eventually expands into an irregularly shaped oval feeding area, where pupation and hibernation also occur. Progeny do not leave the brood tree until the next spring. There is generally one generation per year.

Distribution: Northeast records from Maine, New Hampshire, New York, and Vermont. North American records from Alaska and Newfoundland to northeast British Columbia, Minnesota, and West Virginia.

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Hylurgus ligniperda* (Fabricius). Differs from *D. simplex* in having the frons with a raised longitudinal tubercle near its apex.

References: Bright (1976), Hiratsuka et al. (1995), Hopkins (1909), Rose and Lindquist (1980), and Wood (1963, 1982).

Genus *Polygraphus* Erichson

Members of genus *Polygraphus* are characterized by the solid, unsegmented antennal club (Figure 13g, page 11), the completely divided eye (Figure 4c, page 5), the evenly convex declivity, and the dense, scaly pubescence.

Polygraphus rufipennis (Kirby)

Common name: Four-eyed spruce bark beetle

Diagnosis: Length 1.8-3.1 mm. Body very dark brown to black. Frons flat to concave, with long pubescence (females) or shallowly concave below frontal tubercles (males), surface finely punctured; antennal club narrowly rounded at tip (Figure 13g, page 11); strial and interstrial punctures of elytra confused, moderately small, shallow, close, interstriae indicated by rows of granules; vestiture on elytra and pronotum of white or yellowish scales.

Host species and colonization habits: *Picea* species, *Pinus strobus* and most other conifers in its range. As with other North American species in this genus, *P. rufipennis* usually colonizes recently broken, cut, or fallen trees, but may also attack standing, unhealthy trees or those weakened by the primary invasion of other bark beetles.

Life history: All American species in the genus are polygynous. There is some uncertainty as to whether a male or female or both construct the entrance tunnel and nuptial chamber in the phloem tissues. Ultimately, between two and five females mate with one male, and each constructs her own egg gallery as far away from the others as possible, often resulting in a star-shaped gallery system (Figure 2a, page 4). Females deposit their eggs in large, irregularly placed niches cut into the gallery wall. Larvae burrow in the phloem at right angles to the egg galleries, and pupal cells are constructed at the end of the larval mines. If the climate is favorable, parents may abandon their galleries after egg-laying and produce one or more additional broods elsewhere, either on the same or a different host. As a result, individuals may overwinter as adults, larvae, or pupae.

Distribution: Northeast records from Maine, New Hampshire, New York, and Vermont. North American records from Alaska to New Mexico then eastward to Newfoundland and North Carolina.

Other *Polygraphus* species known to occur in the Northeast: None.

References: Bright (1976), Hinton (1968), and Wood (1982).

Genus *Scolytus* Geoffroy

Members of genus *Scolytus* are characterized by the abruptly ascending abdominal sternites (Figure 9c, page 7) (except *S. rugulosus* and *S. mali*) and by the broad, flattened, unarmed prothoracic tibiae (Figure 10a, page 10). The most obvious characters are on the males, therefore the females may be difficult to identify unless accompanied by males. Males are distinguished by the strongly flattened frons; the frons of females is convex.

Scolytus piceae (Swaine)

Common name: Spruce scolytus

Diagnosis: Length 2.2-3.3 mm. Body very dark reddish brown, pronotum often almost black. Frons flattened to behind the eyes, impressed between eyes (male) or convex, with fine, longitudinal scratches or punctures (female); spine on sternite 2 of both sexes arising from center of sternite, base of spine not touching either anterior or posterior margin of sternite (Figure 19).

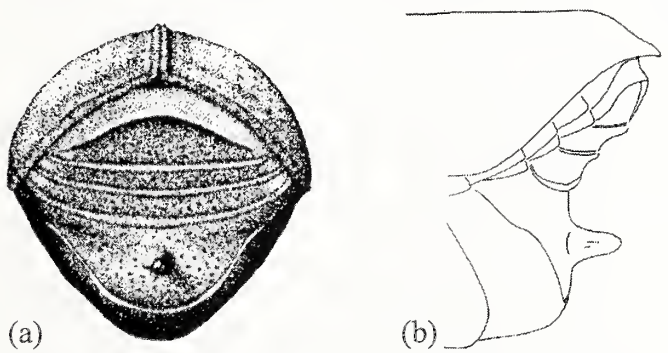


Figure 19. *Abdominal sternite 2 of* ***Scolytus piceae*** *has a spine arising from the center: (a) posterior view; (b) lateral view (reprinted from Edson 1967).*

Host species and colonization habits: *Picea* species; rarely *Abies* and *Larix* species. Colonizes shaded branches of living trees, and dead and dying limbs. Secondary pests, usually do not kill live trees.

Life history: All temperate American species of *Scolytus* are monogynous. The female initiates colonization by excavating a nuptial chamber in the phloem region. She is joined here by one male and, after mating, she constructs an egg gallery comprised of two or, rarely, three branches. If there are two branches they extend in opposite directions; one directly with the grain, the other cutting across the grain at a right angle for a short distance before turning with the grain. If there are three branches, the gallery outline resembles a tuning fork. The female lays between 10 and 30 eggs in deep niches on both sides of the each gallery. Larval mines radiate from the parental gallery at right angles but soon turn to follow the grain. Circular pupal cells occur at the end of the larval mines. The resulting gallery system is fan-shaped and deeply scores the sapwood. In the Northeast there is probably one generation per year.

Distribution: Northeast records from Maine, Massachusetts, and New York. North American records from Alaska to Nova Scotia then southward to California and New York.

Other *Scolytus* species known to occur in the Northeast: *S. quadrispinosus* Say, *S. mali* (Bechstein), *S. multistriatus* (Marsham), *S. rugulosus* (Müller). The last three are introduced species that are now established in the Northeast.

References: Bright (1976), Edson (1967), and Wood (1982).

Genus *Pityogenes* Bedel

Members of genus *Pityogenes* are characterized by the deeply excavated frons of the female (Figure 15a, page 12), the antennal club bearing two sutures on the anterior face and on the distal third of the posterior face (Figure 13b, page 11), and the short, obtuse prosternal intercoxal piece (Figure 16a, page 12).

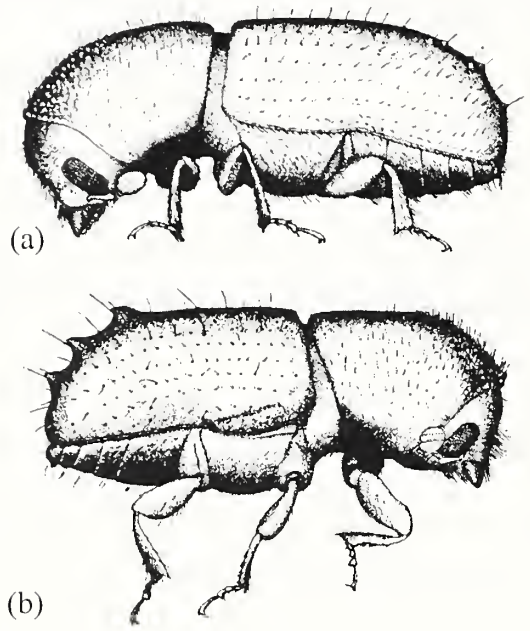


Figure 20. *Lateral views of* ***Pityogenes hopkinsi*** *show differences in the sizes of declivital teeth between females and males: (a) female; (b) male (reprinted from Blackman 1915).*

Pityogenes hopkinsi Swaine

Diagnosis: Length 1.8-2.3 mm. Body brown. Frons of female convex, bearing a deep, circular pit between eyes, the diameter of the pit equal to about one-third of the distance between the eyes (Figure 15a, page 12); anterior margin of pronotum narrowly rounded; pronotal surface on each side of median line brightly shining, with sparse punctures; elytral declivity convex, bearing three teeth on each side of suture, these teeth small and acute (female) (Figure 20a) or larger with upper pair laterally compressed (male) (Figure 20b).

Host species and colonization habits: *Pinus strobus*, rarely *P. resinosa*, *P. banksiana*, and *Picea* species. Typically colonizes the thin-barked tops and limbs of recently dead or dying white pines and also slash. Although this species usually poses no economic threat, it may sometimes attack and kill small, unhealthy pines.

Life history: The polygynous male initiates colonization by constructing an entrance tunnel and nuptial chamber. Here he waits for and mates with three to five females. Each female then excavates an egg gallery that radiates away from the central nuptial chamber, in the cambium, so that the gallery system is ultimately star-shaped (Figure 2b, page 4). Each egg gallery is about 2.5 cm long and contains up to 60 eggs, which the female lays in individual niches. Larval mines radiate away from the egg gallery in an irregular pattern and are visible on the surface of peeled bark. Pupal cells are also located in the cambium at the end of each larval mine, and young adults emerge from individual exit holes.

Distribution: Northeast records from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Vermont. North American records from Minnesota to Newfoundland then southward to Tennessee and North Carolina.

Other *Pityogenes* species known to occur in the Northeast: *P. plagiatus* (LeConte), *P. bidentatus* (Herbst). *Pityogenes bidentatus* is a European species, first reported in North America in 1988, and now established in the Northeast (Hoebeke 1989, Hoebeke 1994).

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Pityogenes chalcographus* (Linnaeus), a Eurasian species introduced to Jamaica. Differs from *P. hopkinsi* in following ways: female has a larger, oval pit on frons, occupying at least one-half (rather than one-third) of the width between the eyes; male *P. chalcographus* has a slightly wider excavation between the rows of teeth on the elytral declivity.

References: Blackman (1915), Bright (1976), and Wood (1982).

Genus *Pityokteines* Fuchs

Members of genus *Pityokteines* are characterized by the long and abundant setae of the frons and anterior portion of the pronotum of the female (Figure 15b, page 12), the obliquely truncate antennal club, which is devoid of sutures on the posterior face (Figure 13c, page 11), the long and acutely tapered prosternal intercoxal piece (Figure 16b, page 12), and the large declivital teeth, especially in the male (female in Figure 14a, page 12).

Pityokteines sparsus (Leconte)

Common name: Balsam fir bark beetle

Diagnosis: Length 1.6-2.5 mm. Body dark brown. Frons flattened (female) to convex (male), surface obscurely punctured, with a weak, longitudinal carina (male) or very densely pubescent (female) (Figure 15b, page 13); anterior margin of pronotum bearing long setae (female); elytral striae not impressed on disk, punctures moderate, in regular rows, interstriae also with punctures, the punctures similar in size to strial punctures; declivity steep; abrupt (male) or more convex (female) with stria 1 impressed, lateral areas with three pairs of teeth, the second pair of teeth larger (male) or with three pairs of small, nearly equal-sized teeth (female).

Host species and colonization habits: *Abies balsamea*. Usually colonizes tops and limbs of injured or fallen trees, but may extend to the lower trunk of fallen trees. While *P. sparsus* has been reported to be a primary enemy of balsam fir (Wood 1982), others have found that the species attacks only weakened trees beyond the recovery stage (Belyea 1952, Hosking and Knight 1976).

Life history: All species within the genus are polygynous. Several egg galleries, each about 2.5 to 3.0 cm long, radiate from an irregularly shaped nuptial chamber, resulting in a star-shaped gallery system. The egg galleries are excavated in the phloem and usually extend transversely across the grain of the wood. Each female deposits just a few eggs in her gallery in large, widely spaced niches. Larval mines are short and usually follow the grain of the wood.

Distribution: Northeast records from Maine, Massachusetts, New Hampshire, New York, and Vermont. North American records from Alberta and Newfoundland to Wisconsin and West Virginia.

Other *Pityokteines* species known to occur in the Northeast: None.

References: Bright (1976), Chamberlin (1939), Hosking and Knight (1976), and Wood (1982).

Genus *Orthotomicus* Ferrari

The genus *Orthotomicus* is intermediate between *Pityokteines* and *Ips*. Like *Pityokteines*, *Orthotomicus* has an obliquely truncate antennal club (Figure 13d, page 11). Like *Ips*, *Orthotomicus* has a more broadly, deeply excavated elytral declivity with an elevated ridge just before the apex (Figure 14b, page 12).

Orthotomicus caelatus (Eichhoff)

Diagnosis: Length 2.4-3.3 mm. Body very dark reddish brown, sometimes lighter. Frons broadly convex, a slight transverse elevation near epistoma, surface granulate-punctate, antennal club obliquely truncate with three recurved sutures (Figure 13d, page 11); elytral striae and interstriae punctured in regular rows; elytral declivity abrupt, steep, broadly excavated, with elevated lateral margins (Figure 14b, page 12); declivital face with three pairs of teeth, the third set well mesad of lateral margins (Figure 14b), teeth of females distinctly smaller; subapical margin of declivity with slightly elevated ridge (Figure 14b).

Host species and colonization habits: Probably any species of *Pinus*, *Picea*, or *Larix* within its range. Most often colonizes the lower trunk or large limbs of standing or fallen recently dead trees, or the stumps of cut trees. Occasionally, this species infests twigs and bark of young trees under stress and may cause tree mortality. Normally, however, *O. caelatus* alone poses little economic threat to its hosts; it usually accompanies the attack of more aggressive species.

Life history: The polygynous adults construct an irregularly radiate gallery system in the cambium. Each female excavates a short egg gallery and deposits between two and six eggs in each egg niche. Larval mines may score the sapwood. Pupation occurs either in chambers constructed in the inner bark or within pits in the sapwood.

Distribution: Northeast records from Connecticut, Maine, Massachusetts, New Hampshire, New York, and Vermont. North American records from Alaska to California then eastward to Nova Scotia and Florida.

Other *Orthotomicus* species known to occur in the Northeast: None.

Similar-looking exotic species screened for by Cavey and Passoa (1994): *O. erosus* (Wollaston). This exotic species has also been put in *Ips* by Wood and Bright (1992). Differs from *O. caelatus* in the following ways: antennal club sutures procurved, rather than recurved; four teeth (rather than three) on the elytral declivity.

References: Bright (1976), Chamberlin (1939, 1958), and Wood (1982).

Genus *Ips* DeGeer

Members of genus *Ips* are characterized by the concave elytral declivity bearing three to six teeth on each lateral margin, the concavity is separated from the apical margin of the elytra by a shelf or elevated ridge (Figure 14c, page 12). Also, the antennal club is flattened, circular to oval, with three visible sutures varying from straight to acutely angulate (Figure 13e, page 11).

Key to three common species of *Ips*

1. Elytral declivity with six teeth on each lateral margin (Figure 21a,b, page 26); sutures of antennal club acutely angled at middle; body length 3.5-6.5 mm ..... ***I. calligraphus* (Germar),** p. 27

   Elytral declivity with four teeth on each lateral margin (Figure 21c-f, page 26); sutures of antennal club bisinuate, neither acutely angled nor straight (Figure 13e, page 11); body length 3.0-4.3 mm 2

2. Elytral interstriae without punctures or setae on disc (Figure 22a, page 26); third tooth of males subcapitate, subacute at tip, often slightly bent ventrad (Figure 21c, page 26); third tooth of female similar to second tooth with an emarginate ridge joining them (Figure 21d, page 26); frons granulate, with single large tubercle on median line midway between upper level of eyes and epistoma ..... ***I. pini* (Say),** p. 28

   Elytral interstriae with punctures and setae on disc (Figure 22b, page 26); declivital armature of males and females similar, third tooth stout and cylindrical rather than capitate, subacute at tip (Figure 21e,f, page 26); frons very smooth (female), sparsely granulate (male), without tubercle ..... ***I. borealis borealis* Swaine,** p. 29

Other *Ips* species known to occur in the Northeast: *I. grandicollis* (Eichhoff) (five declivital teeth); *I. perroti* Swaine, *I. perturbatus* (Eichhoff), (four declivital teeth); *I. latidens* (LeConte) (three declivital teeth)

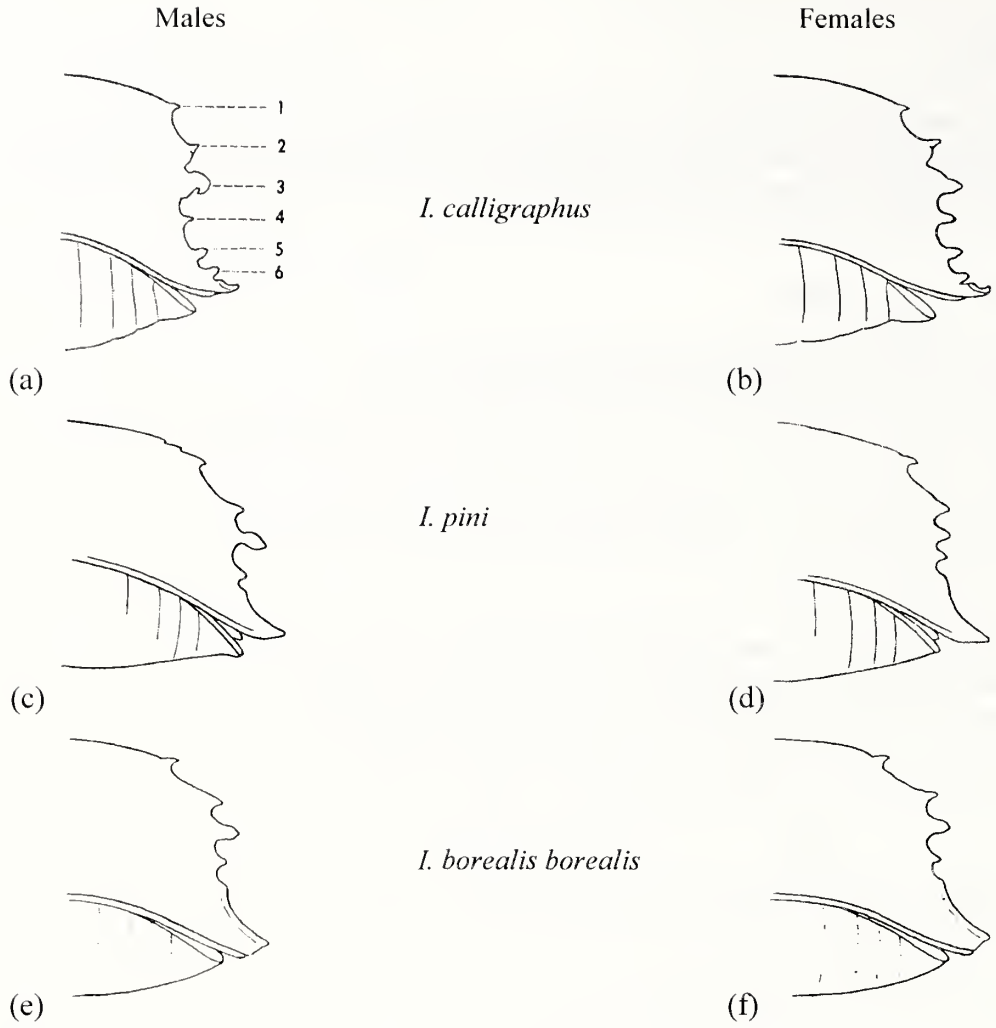
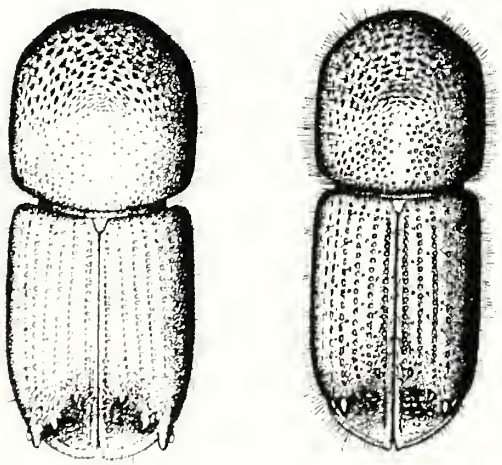


Figure 21. *Lateral views of elytral declivities show the arrangement of teeth in males and females of three Ips species:* ***I. calligraphus****—(a) male, (b) female (reprinted from Hopping 1965b with permission of the Publications Committee of the Entomological Society of Canada);* ***I. pini****—(c) male, (d) female (adapted from Hopping 1964 with permission of the Publications Committee of the Entomological Society of Canada);* ***I. borealis borealis****—(e) male, (f) female (adapted from Hopping 1965a with permission of the Publications Committee of the Entomological Society of Canada).*



(a) *I. pini* (b) *I. borealis borealis*

Figure 22. *Dorsal views of two Ips species show the difference in vestiture on the elytral disc: (a) interstriae without punctures or setae—****I. pini*** *(reprinted from Hopping 1964 with permission of the Publications Committee of the Entomological Society of Canada); (b) interstriae with punctures and setae—****I. borealis borealis*** *(reprinted from Hopping 1965a with permission of the Publications Committee of the Entomological Society of Canada).*

Ips calligraphus (Germar)

Common name: Six-spined or coarse-writing engraver

Diagnosis: Length 3.5 to 6.5 mm. Body dark reddish brown. Frons convex, granulate-setose with a median tubercle above the epistomal margin; antennal club oval, sutures acutely angled; elytral interstriae punctate; elytral declivity excavated, lateral margins with six teeth, the third tooth the largest, notched on ventral side resembling a crochet hook (male) (Figure 21a) or acute to subacute (female) (Figure 21b); vestiture of fine, long hair, more abundant on sides and declivity.

Host species and colonization habits: *Pinus* species. Colonizes stumps, trunks, and larger limbs of recently felled trees; may also colonize and kill apparently healthy trees.

Life history: All species in the genus are polygynous and the male initiates colonization by constructing a large nuptial chamber and excavating rudimentary egg galleries which radiate from the nuptial chamber. In *I. calligraphus*, the male mates with four to six females, who further elongate the egg galleries (14-38 cm) parallel to the grain of the wood, either up or down, often deeply scoring the xylem. Each female lays up to 100 eggs, singly in niches. Larval mines are moderately long and head away from the egg gallery.

Distribution: Northeast records from Connecticut, Massachusetts, New Hampshire, New York, and Vermont. North and Central American records from California and Quebec to Honduras and Jamaica.

Similar-looking exotic species screened for by Cavey and Passoa (1994):
Ips sexdentatus (Boerner) (six declivital teeth). Differs from *I. calligraphus* in the following ways: generally longer body length of 5.5-8.2 mm; the surface of the elytral declivity is dull, not shiny; the fourth declivital tooth is larger than the others; the frons has a short, transverse raised line above the median tubercle.

References: Bright (1976), Lanier (1972), Thatcher (1960), Wilkinson and Foltz (1980), Wood and Stark (1968), and Wood (1982).

Ips pini (Say)

Common name: Pine engraver

Diagnosis: Length 3.3-4.3 mm. Body dark reddish brown to almost black. Frons convex, densely, coarsely punctate above, granulate below, with a short, fine longitudinal carina above epistoma (female) or a median tubercle (male); antennal club elongate-oval, sutures bisinuate and obtusely angled at middle (Figure 13e, page 11); elytral interstriae without punctures or setae on disc (Figure 22a, page 26); declivity deeply excavated, lateral margins with four teeth, the third tooth larger than the others, subcapitate, and bent slightly ventrad (male) (Figure 14c, page 12 and Figure 21c, page 26), or conical, similar to the second with an emarginate ridge joining them (female) (Figure 21d, page 26).

Host species and colonization habits: *Pinus* and *Picea* species, rarely *Larix* species. Colonizes weakened, dying, or fallen trees, large limbs, and slash. Rarely can *I. pini* sustain an attack on healthy trees by itself, although if population levels are sufficiently high they can sometimes weaken healthy trees by infesting their tops. *Ips pini* frequently colonizes the tops and larger limbs of trees simultaneously being infested by *Dendroctonus* and thereby may intensify an outbreak.

Life history: Similar to that of *I. calligraphus* in many respects. The parental gallery system is X- or Y-shaped, with three or four females excavating long, longitudinally oriented egg galleries that radiate out from a central nuptial chamber. Females lay eggs singly in niches on both walls of the egg galleries, and these eggs hatch within about 10 days. The larvae mine at right angles to the egg gallery, across the grain, for about 3 cm. Pupation occurs in a cell at the end of the larval mine and takes about 10 days to complete. There may be one to three generations produced in a year.

Distribution: Northeast records from Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. North American records from Alaska to Newfoundland then southward to Chihuahua and North Carolina.

Similar-looking exotic species screened for by Cavey and Passoa (1994):
Ips typographus (Linnaeus) (four declivital teeth). Differs from *I. pini* in the following ways: longer body length of 4.2-5.5 mm; the declivity is dull, rather than shining, between punctures; and the third declivital tooth on the female is capitate, rather than conical.

Orthotomicus erosus (Wollaston) (four declivital teeth). This exotic species has also been put in *Ips* by Wood and Bright (1992). Differs from *I. pini* in the following ways: the second declivital tooth is larger than the others (on male and female) and broad for most of its length, rather than capitate or conical; the antennal club sutures are procurved, rather than bisinuate.

References: Bright (1976), Reid (1955), Sartwell et al. (1971), Thomas (1961), and Wood (1982).

Ips borealis borealis Swaine

Diagnosis: Length 3.0-3.7 mm. Body dark brown. Frons convex to slightly elevated, entirely smooth, glabrous exeept for conspicuous epistomal brush (female) or finely punetate above, finely granulate below, sparsely pubescent (male); antennal club oval, sutures bisinuate, the second suture more strongly bisinuate; elytral interspaces punctured and with setae on disc (Figure 22b, page 26); elytral declivity excavated, lateral margins with four teeth, the third tooth larger than the others, stouter, more eylindrieal, subacute at the tip (Figure 21e,f, page 26).

Host species and colonization habits: *Picea* species. Presumed to colonize the trunks of unhealthy, cut, or fallen trees.

Life history: The life history of this species has been little investigated, but it shares certain habits with other members of the genus (see life history description for *I. calligraphus*). *Ips borealis borealis* has parental tunnels of a tuning fork pattern, with moderately long larval mines radiating from them.

Distribution: Northeast records from Maine, New Hampshire, and Vermont. North Americean records from Alaska to Newfoundland then southward to Montana, Minnesota, and Maine.

Similar-looking exotic species screened for by Cavey and Passoa (1994): *Ips typographus* (4 declivital teeth). Differs from *I. borealis borealis* in the following ways: longer body length of 4.2-5.5 mm; the declivity is dull, rather than shining, between punctures; the third declivital tooth is capitate (on male and female), rather than cylindrical.

Orthotomicus erosus (Wollaston) (four declivital teeth). This exotie speeies has also been put in *Ips* by Wood and Bright (1992). Differs from *I. borealis borealis* in the following ways: the second declivital tooth is larger than the others (on male and female) and broad for most of its length, rather than eonieal: the antennal club sutures are procurved, rather than bisinuate.

References: Bright (1976) and Wood (1982).

Genus *Dryocoetes* Eichhoff

Members of genus *Dryocoetes* are characterized by the obliquely truncate antennal club that has one or two recurved sutures on the pubescent anterior face and a thickened basal portion occupying more than half the total length (Figure 13a, page 11), the exceedingly broad oral region, and the evenly convex pronotum and elytral declivity.

Dryocoetes autographus (Ratzeburg)

Diagnosis: Length 2.8-5.0 mm. Body dark reddish brown. Frons broad, convex, flattened just above epistoma, surface granulate-punctate, with a few, long, hair-like setae; pronotum widest at middle, sides strongly arcuate from base to rather narrowly rounded anterior margin, anterior two-fifths and lateral surfaces of pronotum finely asperate, remaining area coarsely, deeply punctured; strial punctures large and deep; elytral declivity evenly convex, interstriae 1 feebly elevated, all interstriae with a row of fine granules (female) or without granules (male); vestiture of rows of fine, short strial hair, and rows of much longer, rather fine interstrial hair.

Host species and colonization habits: All species of conifers in its range. Colonizes the base and large roots of dying or injured standing trees, or the trunk of felled or windthrown trees.

Life history: Because the life histories of the species within *Dryocoetes* have not been well studied, the following is a general account for the genus. All species in the genus are polygynous. The male excavates the entrance hole and constructs the nuptial chamber, where he is joined by three or four females. Each female constructs an egg gallery that radiates out from the nuptial chamber, and lays her eggs in niches cut into the gallery wall. The short larval mines wander irregularly. The entire gallery system is excavated in the phloem, and does not score the sapwood. The life cycle is completed in 1 to 2 years and individuals may overwinter as larvae or adults; adults may produce more than one brood.

Distribution: Northeast records from Maine, New Hampshire, New York, and Vermont. North American records from northern coniferous forests south to New Mexico and North Carolina. Also in Northern Europe and Asia.

Other *Dryocoetes* species known to occur in the Northeast: *D. affaber* (Mannerheim), *D. betulae* Hopkins, *D. caryi* Hopkins, *D. granicollis* (LeConte).

References: Bright (1963, 1976) and Wood (1982).

GLOSSARY

Definitions adapted primarily from Borror et al. (1989) and Bright (1976)

Acute: pointed; ending in or forming less than a 90-degree angle.

Anterior: front; in front of; in the direction toward the head.

Apex: the part of a joint or segment that is opposite the base by which it is attached; the posterior portion of the elytra; the anterior portion of the pronotum; the distal portion of the antennal club.

Apical: pertaining to the extreme end, tip, or outermost part of a structure.

Arcuate: arched.

Armature: sclerotized teeth, processes, or coarse sculpturing.

Asperate: having the surface finely or moderately roughened with acute elevations or asperities.

Asperities: small or moderate surface roughenings; from coarse granules to rather prominent elevations, especially the elevations on the anterior portion of the pronotum.

Base: the part of any appendage or structure that is nearest the body; the posterior portion of the pronotum: the anterior portion of the elytra.

Bilobed: divided into two lobes.

Bisinuate: having two sinuations or undulations (Figure 13e, page 11).

Bristle: a short, stiff hair.

Cambium: a thin layer of tissue between the xylem and the phloem in a vascular plant that gives rise to secondary xylem and phloem cells as the plant grows (Figure 1, page 3).

Capitate: refers to a structure in which the distal portion is swollen, forming a subglobular mass.

Carina, carinae: a narrow ridge or keel.

Club: the enlarged terminal part of the antennae (Figure 5, page 6).

Confused: irregular; punctures, crenulations, or pubescence not in regular rows.

Contiguous: touching when in a normal position.

Constricted: evenly but abruptly narrowed.

Coxa, coxae: the basal segment of a leg by which it is attached to the body (Figure 6 and Figure 8, page 6).

Crenulations: small, rounded surface projections; rounded teeth.

Declivity: the usually steeply sloped posterior face of the elytra (Figure 3a, page 5), or the steeply sloping anterior face of the pronotum.

Declivous: sloping gradually downwards.

Disc: the central portion of a major anatomical area, such as the pronotum or elytra; the elytral disc extends laterally from the suture to about the fourth striae and backward to near the declivity.

Distal: pertaining to the portion of an appendage farthest from the body.

Dorsal: of or pertaining to the back or upper side.

Elytron, elytra: the hardened or thickened front wings of beetles which serve as coverings of the hind wings, usually meeting in a straight line down the dorsum (Figure 7, page 6).

Emarginate: with a notch cut from the margin, as in an eye (Figure 4b, page 5), or the distal margin of a tarsal segment.

Emargination: a notch breaking the margin.

Entire: with a smooth, unbroken outline, as in an eye (Figure 4a, page 5); without emargination.

Episternal area: pertaining to the anterior area of the lateral or pleural portion of a thoracic segment, directly above the coxa (Figure 3a, page 5).

Epistoma: the lower portion of the front of the head between the frons and the mouth cavity (Figure 3a, page 5).

Epistomal brush: a linear arrangement of hairs arising from the epistoma

Epistomal margin: the anterior or dorsal margin of the mouth cavity.

Epistomal process: a flattened or convex dorsal prominence arising from the base of the epistoma. with its apex reaching toward the epistomal margin (Figure 3a, page 5 and Figure 18, page 16).

Face: the outer surface of any part.

Femur: the leg segment between the trochanter and the tibia (Figure 8, page 6).
Frass: a sawdust-like material composed of boring dust and excrement produced by the beetle boring in the host plant.
Frons: the front part of the head extending from the epistoma to the upper level of the eyes (Figure 3a, page 5 and Figure 18, page 16).
Funicle: the portion of the antenna between the scape and the club, comprised of one to seven segments (Figure 5, page 6).
Gallery: a system of excavations in the phloem, cambium, or xylem of the host plant where mating, egg laying, feeding, and larval maturation occur; usually consists of an entrance tunnel, nuptial chamber, egg galleries, larval mines, and pupal cells (Figure 2, page 4).
Granulate: having small granules on the surface.
Granules: fine, acute, or blunt grain-like prominences on a surface.
Impressed: imprinted, as if by pressure; having a depressed area or marking.
Intercoxal: between the coxae.
Interstriae: the area between two elytral striae (Figure 7, page 6).
Lateral: of or pertaining to the side.
Medial, median: in the middle; along the body's midline.
Mesad, mesally: toward the midline of the body.
Mesothoracic: belonging to the middle segment of the thorax.
Metathoracic: belonging to the posterior segment of the thorax.
Metepisternum: a narrow triangular plate situated laterally, between the coxae and the elytra, visible for its entire length in all genera except those in the tribes Pityophthorini and Corthylini (not included in this guide) (Figures 3a,b, page 5).
Monogynous: having only one female mate at a time.
Oblique: slanted, diagonal, or inclined; neither parallel nor perpendicular.
Obliquely truncate: applied to the antennal club, club thickened at the base with the apical segments appearing telescoped at an angle (Figure 13a,c,d, page 11).
Obtuse: blunt; an angle greater than 90 degrees.
Oviposition: the laying of eggs.
Phloem: vascular tissue that conducts sugars and other organic molecules from the leaves to other parts of a plant; constitutes the inner bark of a tree (Figure 1, page 3).
Pitch: a resin derived from the sap of various coniferous trees.
Pitch tube: a cylinder of pitch and frass surrounding the entrance hole of a bark beetle, results when a host responds to bark beetle colonization by exuding resin.
Polygynous: having more than one female mate at a time.
Posterior: behind or hindmost part.
Pro-: anterior; used as a prefix meaning before, in front of.
Process: an unarticulated prolongation of any part of the surface.
Procurved: arcuate with the convexity in front (n-shaped); applied to antennal club sutures (Figure 13b, page 11).
Pronotum: the dorsal piece, or sclerite, of the prothorax (Figure 3a, page 5).
Prosternum: the ventral piece, or sclerite, of the prothorax (Figure 6, page 6).
Prosternal intercoxal piece: the median, intercoxal extension of the prosternum (Figure 16, page 12).
Prothorax: the first segment of the thorax (Figure 6, page 6).
Pubescence: a dense or sparse covering of fine hair.
Punctate: bearing punctures.
Puncture: a small impression on the surface of the body, like that made by a needle.
Recumbent: reclining, not erect, applied to hair or scales.
Recurved: arcuate with the convexity behind (u-shaped); applied to antennal club sutures (Figure13d, page 11).
Reticulate: marked with a network of fine, impressed or elevated lines.

Rugose: wrinkled.
Sapwood: vascular tissue of the outer xylem through which most of the water and minerals are conducted from the roots to other parts of a plant (Figure 1, page 3).
Scale: one of numerous flattened outgrowths of cuticle covering part or all of the pronotum, elytra, or both.
Scape: the elongate first segment of the antennae (Figure 5, page 6).
Sclerite: a piece of the body wall bounded by sutures.
Sclerotized: hardened.
Sculpture: the elevated or impressed markings on the surface of the body.
Scutellum: the small circular or triangular piece between the bases of the elytra (Figure 7, page 6).
Seta, setae: a short, stiff, pointed hair.
Setose: having setae.
Sinuate: undulating.
Sinuation: an undulating margin.
Spine: an immovable, elongate, acute process.
Sternite: the ventral pieee, or sclerite, of a body segment, particularly of the abdomen (Figure 3, page 5, Figure 6, page 6).
Stria, striae: the parallel, impressed, usually punctured lines on the elytra from base to apex (Figure 7, page 6); a narrow, impressed line, usually longitudinal.
Sub-: slightly less than the meaning of the word to which it is attached as a prefix.
Suture: generally, a groove or narrow membranous area between sclerites; the longitudinal line on the dorsum marking the junction of the elytra (Figure 7, page 6); a line of juncture between two antennal club segments (Figure 5, page 6).
Tarsus, tarsi: the most distal portion of the leg, immediately beyond the tibia (Figure 8, page 6); divided into five segments in Scolytidae, the fourth segment is difficult to see.
Tibia, tibiae: the leg segment between the femur and the tarsus (Figure 8, page 6).
Tooth: a short, acute process, often conical.
Transverse: crosswise; at right angles to the longitudinal line.
Trochanter: the leg segment between the coxa and the femur (Figure 8, page 6).
Tubercle: a coarse granule or small tooth.
Variegated: having discrete markings of different colors.
Ventrad: toward the underside of the body; downward.
Vestiture: all the surface covering, including all hairs, bristles, seales, and setae.
Xylem: the wood of a tree; composed of the outer live, functioning sapwood surrounding the inner, dead heartwood (Figure 1, page 3).

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INDEX TO BARK BEETLE GENERA AND SPECIES

The index includes Latin and common names of all endemic and exotic species mentioned, but not necessarily described, in this guide. Boldfaced page numbers refer to descriptive treatments. Italic page numbers refer to figures.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1999–705-071